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Quality control in the decentralized production of biosand filters: a pilot workshop in Zambia

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The locally produced, concrete biosand filter is a household water treatment option for improving water quality. As of December 2015, over 830,000 biosand filters had been implemented in 60 countries around the world. Local, decentralized production is an advantage of the technology but also creates challenges with quality control. This paper describes the development, piloting and evaluation of a quality control workshop in Zambia. The overall reaction to the workshop was positive. Based on results from the pilot, CAWST will revise the workshop to better achieve learning outcomes and improve the efficacy of the workshop.

Introduction

Household water treatment and safe storage (HWTS) offers the opportunity for people in vulnerable conditions to improve the quality of drinking water in their homes. Locally produced HWTS options, like the biosand filter (BSF), make it possible to provide affordable solutions to people who do not have access to piped, treated water directly to their homes. The Centre for Affordable Water and Sanitation Technology (CAWST) is a non-profit organization that provides education, training and consulting support services to organizations working in water, sanitation and hygiene. One of the services that CAWST offers is to train local individuals and organizations on how to build, install, operate, and troubleshoot BSFs.

One challenge that has arisen with decentralized production of BSFs and other HWTS products is how to ensure a consistent quality of production. Ngai et al. (2014) analysed 32 BSF project evaluations in 19 countries by different organizations between 2002 and 2012 in order to characterize the global adoption, use and performance of the technology. Although the results of the evaluations were positive overall, several key challenges were identified across multiple evaluations. These key issues were: flow rate; filter fabrication; leaks and cracks; and damaged or incorrectly installed diffuser plates. In some situations, these issues could result in decreased effluent water quality that could go unnoticed by the end-user.

The Intergovernmental Panel on Climate Change (IPCC) defines quality control (QC) as “a system of routine technical activities, to measure and control the quality of the inventory as it is being developed” (IPCC, 2000). QC focusses on maintaining current product quality. Given the extent to which BSFs have been implemented – to date in over 830,000 households in at least 60 countries – QC efforts are needed to ensure that high quality filters are being produced. Organizations involved in BSF production range from single individuals to large international non-profit organizations. Because of the variability within production and context, any proposed QC methods would need to be locally owned, adapted and sustainable.

The objectives of the current study were to develop and pilot a workshop on operational QC in BSF production in order to support local BSF producers to construct high quality filters and, in turn, improve health within the households that rely on the BSF for water treatment.

Methodology

Developing the quality control program

The first step in developing the QC program was to define what “quality” meant in this context. The concept of “quality” is subjective and can differ based on the sector and the organization. Garvin (1987) proposed a strategic framework, which divided quality into eight parameters: performance, features, reliability, conformance, durability, serviceability, aesthetics and perceived quality. For the purposes of this study, the important quality parameters of a BSF were identified as performance (ability of the filter to remove pathogens), reliability, and durability.

Next, the BSF production process was mapped. It was necessary to understand the whole production process and to identify the key points in the process for taking steps toward QC. This was achieved using the process approach principle from International Organization for Standardization (ISO) 9000 (ISO, 2015). The parameters of performance, reliability and durability were transformed into performance requirements, which were connected to key steps and materials within the filter production process.

Inspection and test plans establish inspection or verification activities for ensuring that the process or product is proceeding as planned. For this study, an existing inspection or testing method was identified for each key process step and material defined in the process mapping.

Monitoring is a critical aspect of QC because it enables evidence-based decision-making and continuous improvement, two principles that underlie the ISO 9000 quality management strategy. The proposed monitoring within the QC program needed to be simple and manageable, yet still enable effective QC in operations. As such, the QC program only required the recording and documentation of results of the QC testing methods. To support this, existing forms from CAWST's Monitoring BSF Projects workshop were adapted to fit the QC methodology (CAWST, 2011).

The primary mode of analysis included in the QC program was to apply the concept of a run chart to plot the number of high quality filters as a function of time. The run chart is one of the seven fundamental quality tools developed by Kaori Ishikawa (ASQ, 2013). It plots an aspect of performance as a function of time and can be used to detect large variations, trends and cyclic behaviour in processes.

Workshop design

The QC program was developed into a five-day BSF Quality Control workshop. The goals of the workshop were to help participants understand why it is important to conduct QC, and to increase participants' knowledge and skills around QC processes. The workshop was also designed to increase technicians' awareness of local issues relating to their work, and to provide a sense of empowerment, both of which are factors that contribute to individual motivation (Dieleman et al., 2009).

The majority of the content in the workshop in regards to QC techniques was taken from CAWST's BSF for Technicians Construction Manual (CAWST, 2012). Elements of the monitoring and analysis were adapted from the Monitoring BSF Projects workshop materials (CAWST, 2011).

Two new topics were introduced. The first was the grain size analysis test (GSA), which CAWST sometimes includes in the BSF for Technicians workshop, but inconsistently. CAWST offers consulting support on the GSA and has some supporting materials available. The second new topic was the slump test, a common QC measure for concrete, which is not a formal part of the BSF for Technicians workshop, though it is used in an informal manner by some CAWST International Technical Advisors. The workshop also incorporated basic quality management theories from ISO 9000. An overview of the lesson topics and agenda for the 5-day pilot workshop is presented in Table 1.

Table 1. Overview of the lesson topics and agenda for the pilot BSF Quality Control workshop

Day 1	Day 2	Day 3	Day 4	Day 5
• Workshop Introduction • Defining Quality • Process Mapping • Best Practices and quality assurance (QA) Tests	• Best Practices Inspection • Quality Assurance Tests • Filtration Sand Grain Size Analysis	• User Knowledge Assessment • Giving Effective Feedback • Monitoring • Monitoring Plan	• Situational Analysis • Trend Analysis • Monitoring Form Analysis • Communicating about Quality	• Action Planning • Workshop Closing

The pilot BSF Quality Control workshop was facilitated in partnership with the Zambian organization Seeds of Hope International Partnerships (SoHIP) at their training facility in Ndola, Zambia from May 16-20, 2016. Members of the African Biosand Filter Implementers Network (ABINET) were invited to participate. The ABINET is a network of BSF implementing organizations that share ideas and learnings via an online forum. There were 19 workshop participants from seven implementing organizations across Africa.

Ethics approval

The University of Calgary Conjoint Faculties Research Ethics Board granted ethics approval for this study. To recruit participants, an email was sent out via the ABINET mailing list inviting members to take part in a BSF Quality Control workshop that involved a research study component. Participation in the study portion was voluntary – participants could participate in the workshop and not take part in the study. Explicit consent was obtained from participants, and any identifiable information was de-linked from the participants using an arbitrary ID number. Hard copies of the questionnaires were kept in a locked cabinet, and electronic files related to the research study were encrypted and kept on a password-protected computer.

Data collection and analysis

The primary data collection methods were informal observations and participant questionnaires. The design of the evaluation methodology was based on the Kirkpatrick model for learning evaluation, which focuses on four levels: reaction, learning, behavior change and results (Kirkpatrick, 2008). CAWST relies upon the Kirkpatrick model in training development and evaluation because it is straightforward, easy to understand and apply, and relevant to CAWST's education and training model (Ngai et al., 2014). For the purpose of this study, the results level of learning was not evaluated, because the available resources and duration of the study did not encompass enough time to allow for a return trip to evaluate BSF quality.

The primary author observed the SoHIP production site before the workshop and three weeks after workshop delivery. The questionnaires used Likert scales, yes/no questions and open-ended questions to assess participant reaction, learning and behaviour.

A pre-workshop questionnaire was administered in which participants assessed their project's needs and self-assessed their knowledge on topics to be covered in the workshop. The first post-workshop questionnaire was administered with the same knowledge self-assessment, to evaluate learning. This post-workshop questionnaire also included questions designed to assess participants' reaction to the workshop. In January 2017, a second post-workshop questionnaire was distributed. This questionnaire included questions about changes in behaviour within operations and two direct knowledge assessment questions. The answers to the open-ended questions were coded and examined for emergent themes. The results of the Likert scales were analysed using a paired t-test with the ANOVA General Linear Model.

Results and discussion

Needs analysis

The needs analysis sought to assess participants' understanding of quality, implementation of QC techniques, monitoring behaviours within operations and current operational challenges. Based on analysis of the pre-workshop questionnaire, it was determined that participants had a basic understanding of what constituted a good quality BSF and some techniques that could be used to ensure quality. Participants reported that installation records were commonly collected, but not production records. They reported leaks within the body of the filter to be a re-occurring operational issue. Participants also noted the top three things they wanted to see covered in the workshop out of a possible list of topics. These topics were: the slump test, implementing a QC program, and analysing monitoring information. The workshop was modified to address the needs identified in the needs analysis.

Learning evaluation

Reaction

In the first post-workshop questionnaire, ninety-five percent of participants (18/19) reported that the workshop completely met their expectations, with the same percentage reporting that they found the content to be very relevant. The main reasons participants identified for this satisfaction were the ability to apply new knowledge and the applicability of content to operational needs.

Learning

In the pre- and post-workshop questionnaires, participants assessed their own knowledge of a topic on a Likert scale of 1-4. The largest gains in knowledge were on the following topics: the slump test (2.2 ± 0.4), the filtration sand GSA (1.4 ± 0.6) and implementing a quality assurance program (1.5 ± 0.6). Participants reported a post-workshop knowledge of 3.6/4 for both the slump test and the GSA. "Implementing a quality assurance program" referred to all of the content in the workshop, demonstrating a general gain in knowledge about QC. Participants did not report a significant knowledge gain in measuring standing water height or inspecting the diffuser.

The second evaluation of learning occurred in the second post-workshop questionnaire eight months after the pilot. Due to communication challenges, only eight responses were received, one of which was discounted for most analysis due to clear response bias. Response bias refers to when participants respond differently in order to provide the results they think are expected of them.

The questionnaire assessed knowledge and skills in the areas of the slump test and GSA. Participants from the same production site only submitted one response. For the knowledge-based questions on the slump test, two out of six respondents gave a completely accurate answer, one did not answer the question and the remaining fourgave a partially correct answer. For the knowledge-based GSA question, three gave an accurate, targeted answer, two did not answer the question two one did not know the answer.

Behaviour change

Three weeks after the workshop, the primary author visited the production site at SoHIP to observe if there were changes in behaviour in production due to the workshop. There were no observed changes, though the management staff expressed that they were in the process of manufacturing a slump cone. When asked about Quality vs Time graphs, they expressed interest in the topic and wanted to obtain more information.

Based on these informal observations and the responses to the second post-workshop questionnaire, behaviour change was evaluated for six QC techniques: site inspections, box quality test, slump test, GSA, installation quality test, and quality vs. time graphs. In the questionnaire, participants were asked whether, after the workshop, they changed the way they implemented these techniques and/or the way they collected information. Because only seven responses were collected for the second post-workshop questionnaire, these responses were qualitatively but not quantitatively analysed.

There were no observed changes in implementation within the categories of the GSA, installation quality test or quality vs time graphs. For site inspections and the box quality test, there was a low reported change in implementation. In this group of participants, there was an observed familiarity with site inspections. This is logical, as the site inspection content is included in the existing BSF for Technicians workshop. The box quality test is a technique from the BSF for Technicians Construction Manual, which participants had before the workshop (CAWST, 2012). However, it seems that participants did not have much prior knowledge of the test nor experience with its implementation. Use of this test would allow producers to determine whether there is an impediment to water flow in advance of installation and is therefore a positive intervention for production operations.

The slump test showed the highest knowledge gain and implementation rate within the workshop topics, which is logical as the slump test had not been used before in the context of the BSF. However, the gains in learning did not directly correspond to behaviour change. The most commonly cited reason for not implementing this technique was difficulties in sourcing the slump cone. So, although participants learned about the slump test, they were unable to fully implement it due to practical issues.

For all tests that participants reported implementing, they also reported collecting monitoring information. Although collecting monitoring information aids in operational trouble-shooting, the greatest value of monitoring lies in the analysis of the data collected. However, in the second post-workshop questionnaire, no participants reported using the Quality vs Time graphs, the information analysis technique taught within the workshop. All the comments requested that more time be spent on this subject, as the learning was insufficient. This is corroborated by the low self-reported knowledge gain on this topic (1.0 ± 0.7). Future deliveries of this workshop should spend more time on this topic.

Limitations

The second post-workshop questionnaire only elicited seven responses, which may affect the verity of the collected results. This type of bias is referred to as non-response bias, which occurs when those that respond are more pre-disposed to do so because they have a positive response to report (PennState, 2017). However, it should be noted that participants were given the option of completing the questionnaires as an organization as organizations typically only had one production site. There were only seven attending organizations. There was also response bias which affects the veracity of the collected answers. Coupled with a small sample set, response bias is a major limitation and needs to be acknowledged while drawing conclusions from this study.

Although the QC methodology developed here has theoretical support, it has not been proven to improve quality. Therefore, the behaviour changes observed from this study is not directly representative of successful QC within operations. Further studies are needed to examine the direct effect of the workshop on BSF quality.

Conclusions

A quality control methodology was developed to train CAWST clients to conduct quality control within their own BSF production. The workshop was piloted in Ndola, Zambia in partnership with SoHIP with participants from the ABINET. Overall, the workshop elicited a positive reaction from participants. Participants expanded their knowledge about quality control, with the most significant perceived knowledge gains in the slump test and grain size analysis. Learning on the topic of the slump test was corroborated with a direct knowledge assessment. There was evidence of limited behaviour change, most notably in the use of the slump test. Behaviour change for the slump test was reported to be in progress, though more practical support is needed for full implementation. Ultimately, the quality control workshop improved participants' knowledge and impacted their behaviour on implementation of the slump test. Based on these results, the workshop will be revised to increase the efficacy of the workshop at improving quality in BSF production.

Recommendations

Each organization had very different needs. It is recommended that a thorough needs analysis is conducted pre-workshop to better tailor the workshop to meet participant needs. The workshop may be better utilized as an individual organizational support tool to increase the implementation of strategies addressed in the workshop. Alternatively, the workshop could be changed to focus on practical strategies and omit the higher-level knowledge aspects to better meet the needs of technical implementers who solely want to solve practical issues they are facing within their operations.

Future studies should re-evaluate the effectiveness of the revised workshop at influencing behaviour change through use of a different research methodology. Use of survey responses to assess learning and behaviour change was difficult within this case study because of the limited number of respondents and inherent response bias. A more direct methodology to examine the effect on the quality of BSFs produced should be used in order to eliminate subjective biases that influence the credibility of the collected responses.

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